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State of Utah

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Michael O. Leavitt
Governor
Kathleen Clarke
Executive Director
Lowell P. Braxton
Division Director

1594 West North Temple, Suite 1210
PO Box 145801
Salt Lake City, Utah 84114-5801
801-538-5340
801-359-3940 (Fax)
801-538-7223 (TDD)

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TO: Internal File

THRU: Daron Haddock, Permit Supervisor

FROM: Gregg Galecki, Reclamation Hydrologist III

RE: Response to Informal Conference Order, Hiawatha Coal Company, Hiawatha Mine, C/007/011

SUMMARY:

The following analysis is in response to a Division Order dated May 1, 2002, ordering the Division to prepare a Palmer Hydrologic Drought Index (PHDI) analysis of Big Bear Spring, utilizing the Division's water monitoring database. The Division Order was in response to an informal conference conducted April 11, 2002, held at the request of Craig Smith, Nielsen and Senior, for Huntington-Cleveland Irrigation Company (HCIC). The informal conference addressed concerns involving the permit renewal for the Hiawatha Coal Company, Hiawatha Coal Mine, C007/011, Carbon County, Utah.

The following analysis addresses only the correlation between flow at Big Bear Spring (and associated other springs) and the Palmer Hydrologic Drought Index. To also determine the potential effects of the Hiawatha Complex Mine on Big Bear Spring, the correlation between flow at the spring and the water being diverted to the Mohrland portal will also be assessed. Caution should be used when drawing conclusions of mining impacts due solely to a comparison of spring-flow and the Palmer Hydrologic Drought Index (PHDI). Complex geology and potential impacts of other mining activity located in the area also may affect spring-flow at Big Bear Spring. A more comprehensive and in depth analysis of the surrounding hydrology is addressed in the Hiawatha Complex Mine Plan and the Division's Cumulative Hydrologic Impact Area (CHIA) report. As per the Division Order, both the mine plan and CHIA are currently in the process of being updated.

TECHNICAL ANAYLSIS:

Big Bear Spring History

Coal mining in the Gentry Mountain area, where Big Bear Spring is located, began in 1917 in the vicinity of the Star Point Mine. Mining associated with the Bear Canyon Mine began in 1938, and mining in the vicinity of the Hiawatha Mine began in 1948. The variability of flow quantity at Big Bear Spring has been a concern for some time. A similar informal conference was held in February 1997 involving the potential impacts the Bear Canyon Mine was having on the Spring. Numerous studies have been made concerning the effects of mining on Big Bear Spring, namely the Division's Gentry Mountain Cumulative Hydrologic Impact Area study (CHIA), which was most recently revised June 21, 2001, and two additional Probable Hydrologic Consequence studies conducted by EarthFax for the Starpoint Mine, and Mayo and Associates for the Bear Canyon Mine; both completed in 2001. This report reconsiders only a portion of the earlier studies, primarily the relationship of the current flow pattern of Big Bear Spring to the Palmer Hydrologic Drought Index (PHDI). A complete evaluation of the potential effects of mining will be addressed in the Mine's Probable Hydrologic Consequence (PHC) report and the Division's Cumulative Hydrologic Impact Area (CHIA) report.

Palmer Hydrologic Drought Index (PHDI)

In 1965, W.C. Palmer developed an index to provide measurements of moisture conditions that were standardized so that comparisons using the index could be made between locations and months. The index responds to weather conditions that have been abnormally dry or abnormally wet. The PHDI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. Human impacts on the water balance are not considered.

The three primary positive characteristics of the index include: 1) providing a measurement of the abnormality of recent weather for a region; 2) places current conditions in historical perspective; and 3) provides spatial and temporal representations of historical droughts. However, there are also limitations when using the Palmer Index as well. Those include: 1) the values indicating a drought or wet spell were arbitrarily selected based on Palmer's study of central Iowa and western Kansas (Table 1); 2) Snowfall, snow cover, and frozen ground are not included in the index indicating all precipitation is treated as rain, and 3) the natural lag between when precipitation falls and the resulting runoff is not considered. Several states, including New York, Colorado, Idaho, and Utah use the Palmer Index as one part of drought monitoring systems. In the closing remarks of his 1965 'landmark' paper Palmer concluded, "Extrapolation beyond the circumstances for which (the index) was designed may lead to unrealistic results." Indicating caution should be used in its application and that the index should not be used as an absolute indicator for determining impacts of flow on a given water source. The index is a good tool to track the relative changes over time to make some general comparison to historic precipitation patterns.

Table 1

Palmer Classifications	
4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to –0.49	Near normal
-0.5 to –0.99	Incipient dry spell
-1.0 to –1.99	Mild drought
-2.0 to –2.99	Moderate drought
-3.0 to –3.99	Severe drought
-4.0 or less	Extreme drought

The Hiawatha Mine and Big Bear Spring are located on the boundary of three different Palmer Hydrologic Climatic precipitation regions, Region 4 – South Central zone, Region 5 – Northern Mountains zone, and Region 7 – Southeast zone, respectively (Figure 1). Due to weather patterns and elevation Zone 4 and/or Zone 5 best represent the area around Big Bear Spring. A comparison of Zones 4 and 5 was conducted and determined both suited the area. Region 5 was used in the report to be consistent with its use in the Gentry Mountain CHIA. Additional information on the Palmer Hydrologic Drought Index is also available in the following technical paper: Correlation Between Natural Spring Flow and the Palmer Hydrologic Drought Index by Michael J. Suflita (UDOGM), and John W. Kern (Ph.D. – Spectrum Consulting Services, Inc.).

General Geology

The Big Bear Spring and the extreme northwest portion of the Hiawatha Mine are mapped within the Bear Canyon Fault Graben. The portion of Hiawatha Mine that is within the Bear Canyon Fault Graben is located approximately 6.5 miles north of Big Bear Spring. Located between the Hiawatha Mine and the Big Bear Spring are portions of the Star Point Mine and a significant portion of the Bear Canyon Mine (See Figure 2 - Gentry Mountain Geology map). In-mine geologic information indicates vertical displacement of the fault block in the Bear Canyon Graben is approximately 250-feet and is bounded by 10 to 20 feet of fault gouge (pulverized clay-like material formed by the grinding of rock as the fault develops), which has been known to act as a barrier for water to be transmitted from the surrounding area. The graben trends N 4° W, and ranges from 1,600 feet to 2,400 feet between major boundary faults. The dip in the Bear Canyon Graben is southeast and flow moves toward the Bear Canyon Fault. East of the Bear Canyon Fault, dip within the mined-areas and direction of ground-water movement varies from southwest to southeast and then follow old workings to the Morhland portal. Localized variations within the coal seams may determine the ultimate direction of water flow following mining.

The principal geologic controls that affect the presence of ground water in the Gentry Mountain area are: extensional or boundary faults and grabens, local faults and fissures, aquitards such as clay or Mancos Shale, channel sandstones, and structural dip. Except where fractures are actually opened by tension, shales and siltstones in the formations hinder the vertical movement of ground water. Most springs having flows in excess of 10 gpm, (such as the springs in this analysis) lie either: 1) directly along a fault, 2) in close proximity to a fault, or 3) appear to fall in line with the projection of a fault. Ground water tends to flow more readily through shallower systems because the hydraulic conductivities are generally larger that those of deeper systems, but some of the ground water will flow along deeper slower flow-paths. The hydraulic flow path of ground water along joints, fractures, and faults is extremely complex, and the volume or rate of recharge down a fault is difficult to quantify. Springs in the region that are associated with faults have a quick recharge response. At the Hiawatha Mine in the mid – 1970s, an inflow of 900 to 1,000 gpm occurred where the workings contacted the Bear Canyon Fault in the 10th West Section of the U.S. Fuels King IV Mine (Star Point MRP). The flow soon diminished to a fraction of that flow.

Both vertical and horizontal hydraulic conductivities within the Blackhawk and Starpoint Formations are relatively low[1]. For areas of the Hiawatha Complex Mine to recharge Big Bear Spring, there must be communication through secondary faulting and fractures. Although secondary faulting may be possible, no such secondary faulting has been documented.

Spring-flow / PHDI Comparison

A total of four springs and the Mohrland portal discharge were compared to the PHDI in an effort to analyze any trends associating flow with mining activities from the Hiawatha Mine. An inherent difficulty exists in trying to find springs that are within the same geolgic setting and area, are not influenced by mining, and have been accurately monitored for a significant period of time. Included in this analysis are Big Bear Spring, located within the Bear Canyon Fault Graben; Upper Tie Fork Spring, located west of the Bear Canyon Fault Graben; Birch Spring also located west of the Bear Canyon Fault Graben; and Colton Spring located outside the area potentially influence by mining activity and not associated with the Bear Canyon Fault. Colton Spring is located approximately 20 miles due north of the Gentry Mountain area, and discharges from the contact of the Flagstaff Limestone and Colton Formation. Colton Spring is stratigraphically higher than Big Bear Spring however, it is used as a comparison because 1) it has reliable data records 2) it has no known impacts from mining, and 3) was studied extensively in the technical paper by Mike Suflita (DOGM). In addition, the spring is located at the edge of the Utah 'Coal Crescent' where the majority of the state's coal mining activity is located. It is also located within the same PHDI region as Big Bear Spring.

Big Bear Spring to Colton Spring Comparison

When making comparisons to the Palmer Hydrologic Drought Index (PHDI), data is

[1] According to Price and Arnow (1974), the upper Blackhawk Formation sediments have a low hydraulic conductivity and specific yield of 0.2 to 0.7 percent.

commonly recorded on a monthly basis. Figures 3 and 4 compare the spring flow at Big Bear Spring and Colton Spring to the PHDI on a monthly basis. Figure 5 and 6 illustrate the same data at Big Bear Spring and Colton Spring, but smoothed to compare flow to the PHDI on an annual basis. An intuitive observation of the graphs suggests Colton Spring corresponds to, or 'shadows' the PHDI fairly well. Big Bear Spring however, intuitively appears to track well from 1980 through 1992 but seems to deviate from the index from approximately 1993 through 2001. The Hiawatha Complex Mine last operated in the first quarter of 1993.

Although twenty-one years of data is a significant amount of information, when comparing the number of wet/dry cycles since 1920, the available data for both Big Bear Spring and Colton Spring covers only one dry cycle and two wet cycles; the cycle of mid 1979 through mid 1986 being the wettest on record during the 1920-2001 period (Figures 7 and 8). A reduction from the peak flows observed in 1984 would be anticipated. It is difficult to draw the conclusion that flows observed in the 1981 – 1986 period are representative of anticipated flows for Big Bear Spring when comparing it to flows of only two wet cycles and one other spring (Colton).

Both Big Bear Spring and Colton Spring had high flows in 1984 (Figure 9). The springs are generally responding with changes in flow with only a few exceptions. Big Bear Spring had annual mean flows higher in 1980 than 1984 even though 1980 was a dryer year, and Big Bear Spring seemingly did not recover from the 1986 – 1992 drought period as well as Colton Spring. A closer observation of the 1986 – 1992 drought period shows flow at Big Bear Spring decreased 52 percent (low in 1990) from the 1984 peak flows, while flow at Colton Spring decreased 45 percent (low in 1992) from the 1984 peak flows. Flows at Big Bear Spring have continued to increase and are currently at 67 percent of the 1984 peak flows. Correspondingly, flows at Colton Spring have generally increased and are currently at 75 percent of the 1984 peak flows. For the 21 years of available data, the average mean annual flow at Big Bear Spring is 159 gpm, and the mean annual flow for 2001 was 154 gpm. Similarly at Colton Spring, the average mean annual flow is 1617 gpm and the mean annual flow for 2001 was 1642 gpm. This comparison could be interpreted to indicate current flows are at anticipated rates or slightly high considering the index reflects the second year of a dry cycle.

Spring flow to Hiawatha Discharge Comparison

To establish a comparison of what flows from Hiawatha Mine could potentially impact Big Bear Spring, UPDES discharge points UT0023094-001 and UT0023094-002 have been used. UPDES discharge points 001 and 002 emanate from the Mohrland portal located in the Left fork of Cedar Creek and represent essentially all the water discharging from the mine. The combination of the general strike and dip of the geology, and old mine workings in the southern portion of mine allows water encountered in the mine to be gravity-fed to the Mohrland portal and discharged. Data was missing from 1986 through 1988, but has been interpolated in the graphs as 'baseline' flow.

Figure 10 compares discharge from the mine to the Palmer Hydrologic Drought index. It does not consider any outside effects such as diversions of water underground or mining activity. Generally, the graph illustrates that the discharge from the portals reacts independently of the

PHDI. Although the discharge does appear to mimic the PHDI from 1989 through 1995, it does not appear to correlate the rest of the time.

Figure 11 is the same as Figure 9 but adds the discharge rate from the Hiawatha mine. It could be theorized that the increased water reporting to the Mohrland portal from 1992 through 1995 prohibited flows at Big Bear Spring from recovering as quickly as Colton Spring. The possible effects to Big Bear Spring from water being diverted to the Mohrland portal could also be supported with 1996 data showing a 23 percent increase in flow at Big Bear Spring and a corresponding 48 percent decrease in discharge from the Mohrland portal. However, disclaimers should include that mining had ceased in 1993[2], the areas that were being mined were not near the Bear Canyon Fault, and age-dating of the water from both sources indicate they are of different age.

Upper Tie Fork Spring Comparison

Upper Tie Fork Spring is located west-southwest of Hiawatha Mine. However, in-mine geologic information indicates it is also located west of the western edge of the Bear Canyon Fault Graben and south of Starpoint Mine workings (Figure 2). When compared to the PHDI (Figure 12), minimal correlation appears to exist. The wet period of 1980 – 1986 showed apparently average flows with increasing flows during the first half of the 1986 – 1992 dry cycle. Intuitively, the spring appears to be approximately ½-cycle behind the index with the exception that current flows are higher than would be anticipated when compared to the 1980 – 1986 wet cycle. Current flows are 34 percent higher than flows observed during the 1980 – 1986 wet period, and according to the index in the third year of a dry cycle.

Figure 13 compares the flow at Upper Tie Fork Spring to discharge from the Mohrland portal (001 + 002). Observations of the 1992 – 2001 period show a reciprocal trend, particularly in the 1995 – 2001 period. As discharge flow was significantly reduced in 1995, flows at Upper Tie Fork Spring significantly increased. However, assuming water reporting to the Mohrland portal is the only factor influencing flow at the spring, current flows would not be 34 percent higher than flows recorded during the 1980 – 1986 wet period.

Birch Spring Comparison

Birch Spring is located less than a mile northwest of Big Bear Spring. However, in-mine geologic information indicates it is west of both the Bear Canyon Fault Graben and Blind Canyon Fault (Figure 2). Figure 14 illustrates the flow reacting inversely to the PHDI. High flows are observed during the second half of the 1986 – 1992 dry cycle (32 gpm), low flows during the second half of the 1992 – 1999 dry cycle (17 gpm), and current high flows (27 gpm) during a dry cycle.

Figure 15 compares flow from the spring is compared to discharge flows from the Mohrland portal (001 + 002). Similar to Upper Tie Fork Spring, general observations of the

[2] Production numbers reported to MSHA for the 1990 – 1993 period indicate 584,000 tons (1990), 197,000 tons (1991), 108,000 tons (1992), and 13,500 tons (1993) of coal were mined, respectively.

1992 – 1996 period appear to show an inverse trend when comparing Spring flow to discharge flow. However, based solely on flow data and independent of the PHDI conditions the Spring-flow rate would be higher based on the current lower discharge rate.

RECOMENDATIONS:

To make a conclusive statement as to the effects of mining from the Hiawatha Complex Mine to flow at Big Bear Spring, based solely on a comparison of flow data to the Palmer Hydrologic Drought Index is premature. Other variables that need to be considered in addition to continued flow monitoring at Big Bear Spring include continued age-dating and chemistry of the respective waters, additional detailed subsurface geology information, a comparison of coal extraction over time, and a comparison of in-mine flow rates and diversions vs. coal extraction vs. location. A potential for communication of waters between in-mine flows at the Hiawatha Complex Mine and Big Bear Spring cannot be ruled out. Over a long period of time, the comparison of spring flow to the Palmer Hydrologic index provides a valuable tool in quantifying the effects of mining. However, although the comparison spring flow to the PHDI is tracking some interesting patterns, it does not provide conclusive evidence as to the effects of mining on Big Bear Spring.

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